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Annual and seasonal climatic variability at different locations of Punjab state

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ABSTRACT

Annual and seasonal variabilities in maximum, minimum temperature and rainfall were analyzed from historical daily meteorological data for Amritsar (1970-98), Patiala (1970-98), Ludhiana (1970-99) and Bathinda (1977-98). Two distinct crop growth seasons of *kharif* (1 May to 31 October) and *rabi* (1 November to 30 April) were characterized for seasonal trends. Both annual as well as seasonal maximum and minimum temperatures exhibited small standard deviation and coefficient of variation at all stations indicating minor variations in temperatures. The maximum temperature had remained near normal for all the locations while showing a variation of upto ± 0.6°C from normal as revealed from the five yearly moving average. However, the minimum temperature had generally increased by as much as 0.4 to 1.6°C above normal. The annual as well as seasonal rainfall exhibited high standard deviation and coefficient of variation indicating large variations in rainfall at all stations. The five yearly moving average trend in rainfall showed an overall increase of about 120 mm at Amritsar, 150mm at Ludhiana, 150mm at Patiala and 140mm at Bathinda.

Key Words : Climatic variability, Trends.

Crop productivity of a region is largely determined by its climate and prevailing weather. Recent reports reveal that climate is changing due to an increase in the concentration of green house gases in the atmosphere (Hundal and Abrol, 1991). The mean global surface temperature exhibited an increase over the last decades with particularly sharp increase since the 1970's (Gadgil, 1996). The all-India mean annual surface temperature derived from 73 stations across India showed a significant warming of 0.4 °C over the past 100 years which is comparable to global mean trend of 0.3 °C increase per 100 years (Hingane *et al*, 1985). Temperature and rainfall are the two important parameters which affect crop growth and production. A simulation study to analyse climate change impact on crop productivity in Punjab revealed that increasing temperature trends pose a serious threat towards decreasing growth and yield of cereal and oilseed crops (Hundal and Prabhjyot-Kaur, 1996).

Hundal *et al* (1997) analysed rainfall at Ludhiana over the past 95-years and reported an increasing trend over normal for both annual as well as kharif season rainfall in the past 30 years at Ludhiana. Hundal and Prabhjyot-Kaur (2001) had also reported gradually increasing minimum temperature (of about 0.4 to 1.6 °C) over the past 30 years at Ludhiana. Keeping in view the importance of climatic variability, the present study was undertaken to assess changes in rainfall and temperature at different locations in

Table 1: Annual, *kharif* and *rabi* season temperature and rainfall features at four locations in Punjab

Time series/ Location	Maximum temperature			Minimum temperature			Rainfall		
	Average (°C)	S.D.	C.V. (%)	Average (°C)	S.D. (%)	C.V	Total (mm)	S.D. (%)	C.V
Annual									
Amritsar	30.3	0.62	2.1	15.3	0.57	3.7	737	186.4	25.3
Patiala	29.9	0.49	1.6	17.4	0.39	2.2	817	300.4	36.8
Ludhiana	29.7	0.56	1.9	16.2	0.76	4.7	766	233.9	30.5
Bathinda	31.4	0.76	2.4	16.7	0.52	3.1	587	179.0	30.5
***Kharif* season**									
Amritsar	35.6	0.72	2.0	22.6	0.65	2.9	589	176.0	29.9
Patiala	34.8	0.55	1.6	23.7	0.46	1.9	681	287.4	42.2
Ludhiana	34.9	0.62	1.8	22.8	0.83	3.6	638	237.5	37.2
Bathinda	36.8	1.03	2.8	23.7	0.77	3.2	484	193.3	39.9
***Rabi* season**									
Amritsar	24.9	0.81	3.3	8.3	0.69	8.3	172	109.1	63.1
Patiala	25.1	0.71	2.8	11.0	0.55	4.8	136	95.2	69.6
Ludhiana	24.4	0.75	3.1	9.5	0.81	8.5	129	73.4	56.8
Bathinda	27.1	0.90	3.3	10.1	0.68	6.7	108	47.9	44.0

Punjab.

MATERIALS AND METHODS

The variability analysis was carried out by analyzing historical data of temperatures and rainfall for Amritsar (31°37' N, 74°53' E, 231m a.m.s.l), Patiala (30°20' N, 76°28' E, 251m a.m.s.l), Ludhiana (30°56' N, 75° 48' E, 247m a.m.s.l) and Bathinda (30°12 N, 74° 57 E , 211m a.m.s.l). The daily maximum and minimum air temperatures and rainfall data of past 29 years (1970-98) at Amritsar and Patiala; 30 years (1970-99) at Ludhiana; and 18 years (1977-98) at Bathinda were analyzed for annual as well as *kharif* (1 May to 31 October) and *rabi* (1 November-30 April) crop growing seasons, five-year moving averages, standard deviation (s.d.) and coefficient of variation (c.v.).

RESULTS AND DISCUSSION

Temperature

a. Annual trends

The standard deviation (s.d.) and coefficient of variation (c.v.) for all the four stations were small for maximum and minimum temperatures indicating only minor year to year variation. The maximum temperature gave a s.d. between 0.49 and 0.76 °C and c.v. between 1.6 and 2.4 percent (Table 1). The minimum temperature variability showed s.d. ranging from 0.39 to 0.76°C and c.v. of 2.2 to 4.7 percent.

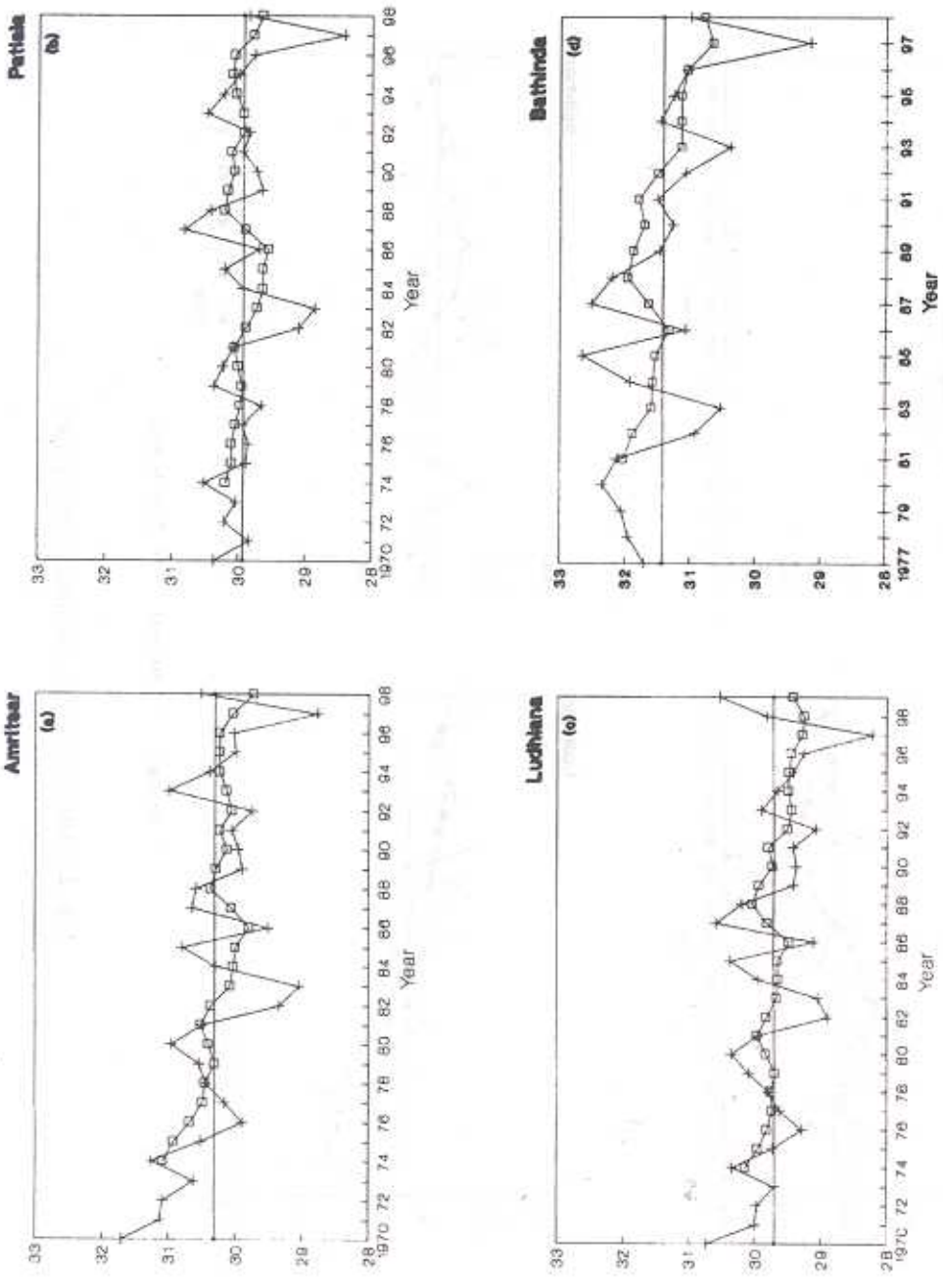

Fig. 1 : Annual average maximum temperature

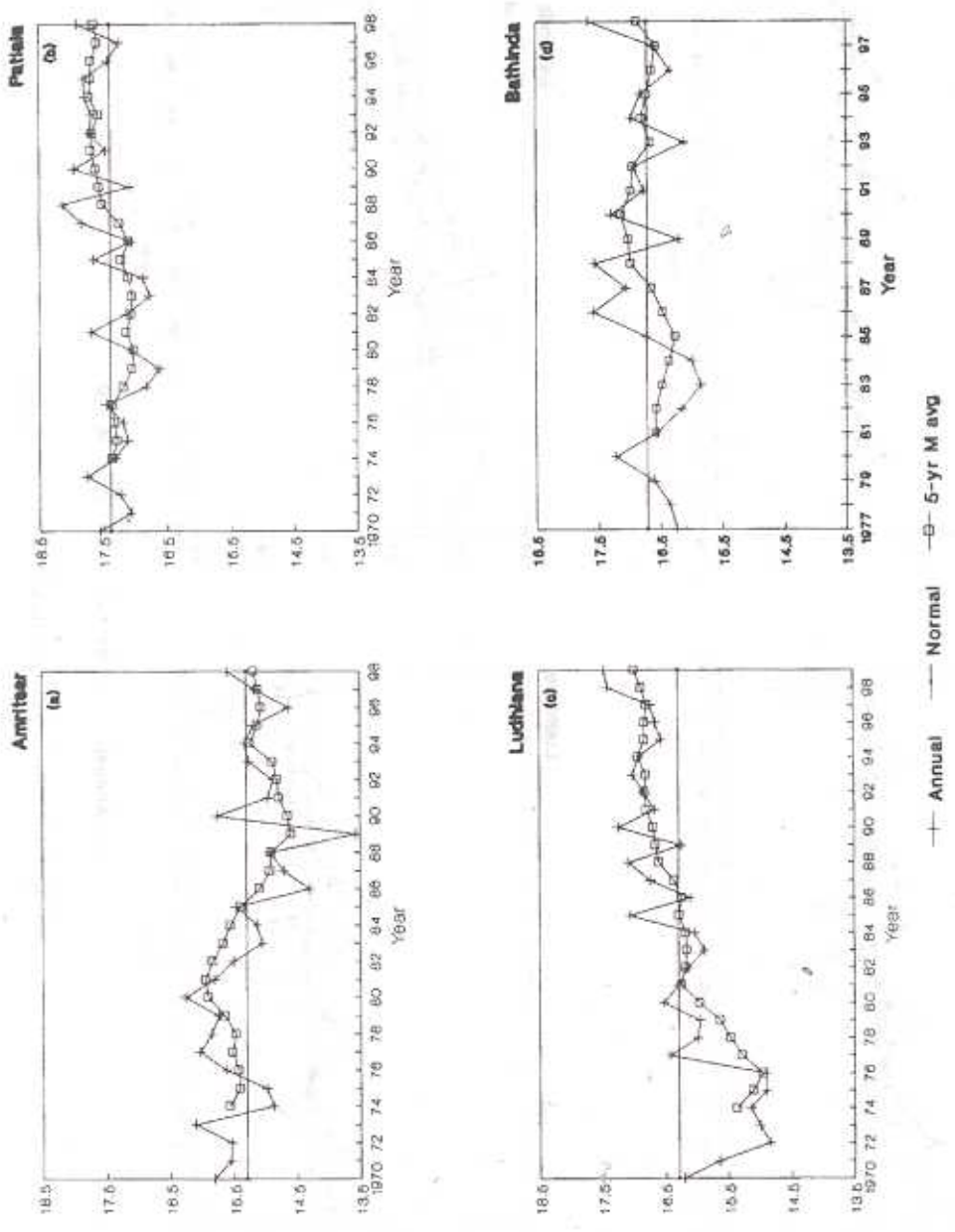

Fig. 2 : Annual average minimum temperature

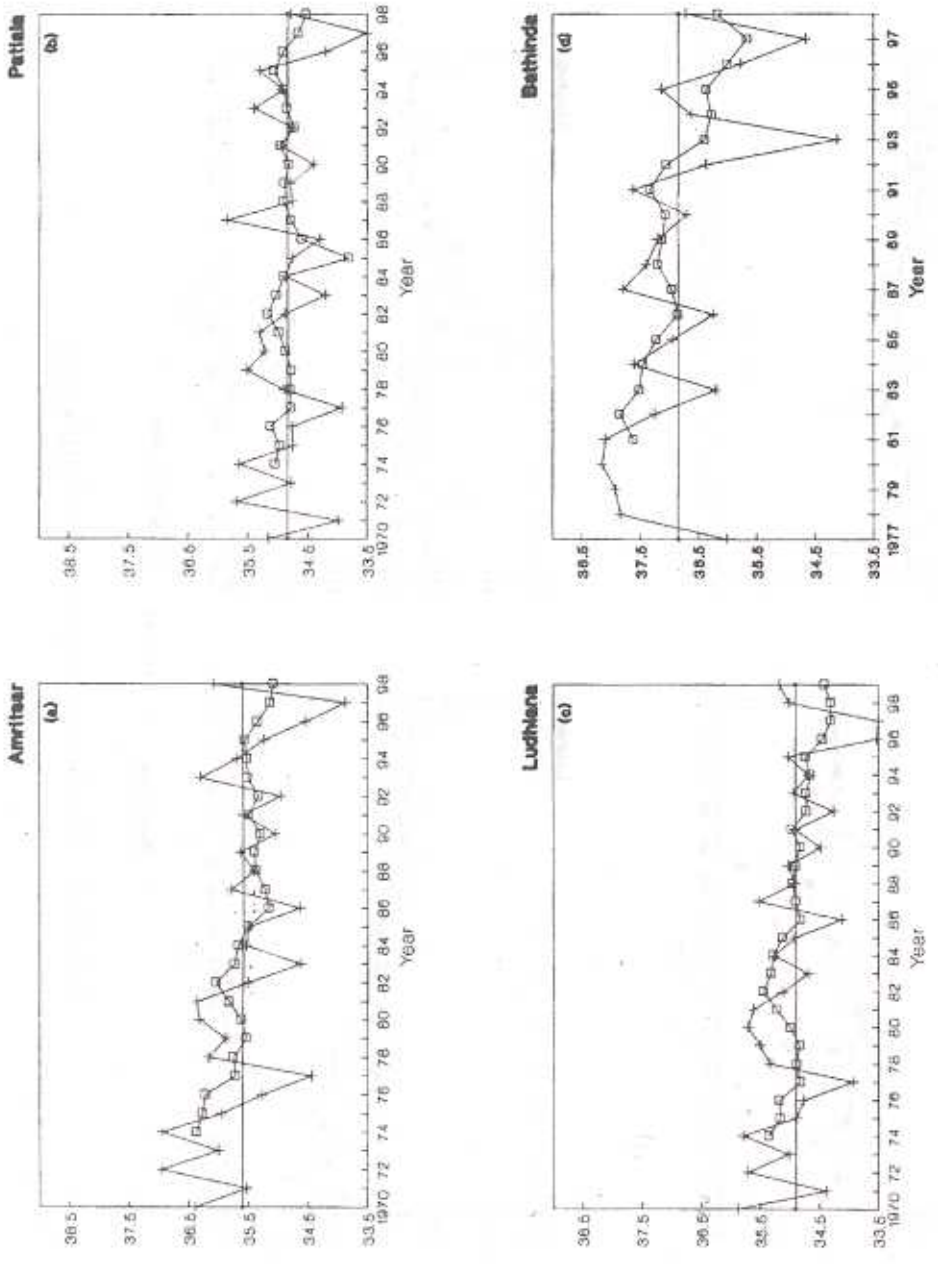

Fig. 3 : Annual maximum temperature for *kharif* season

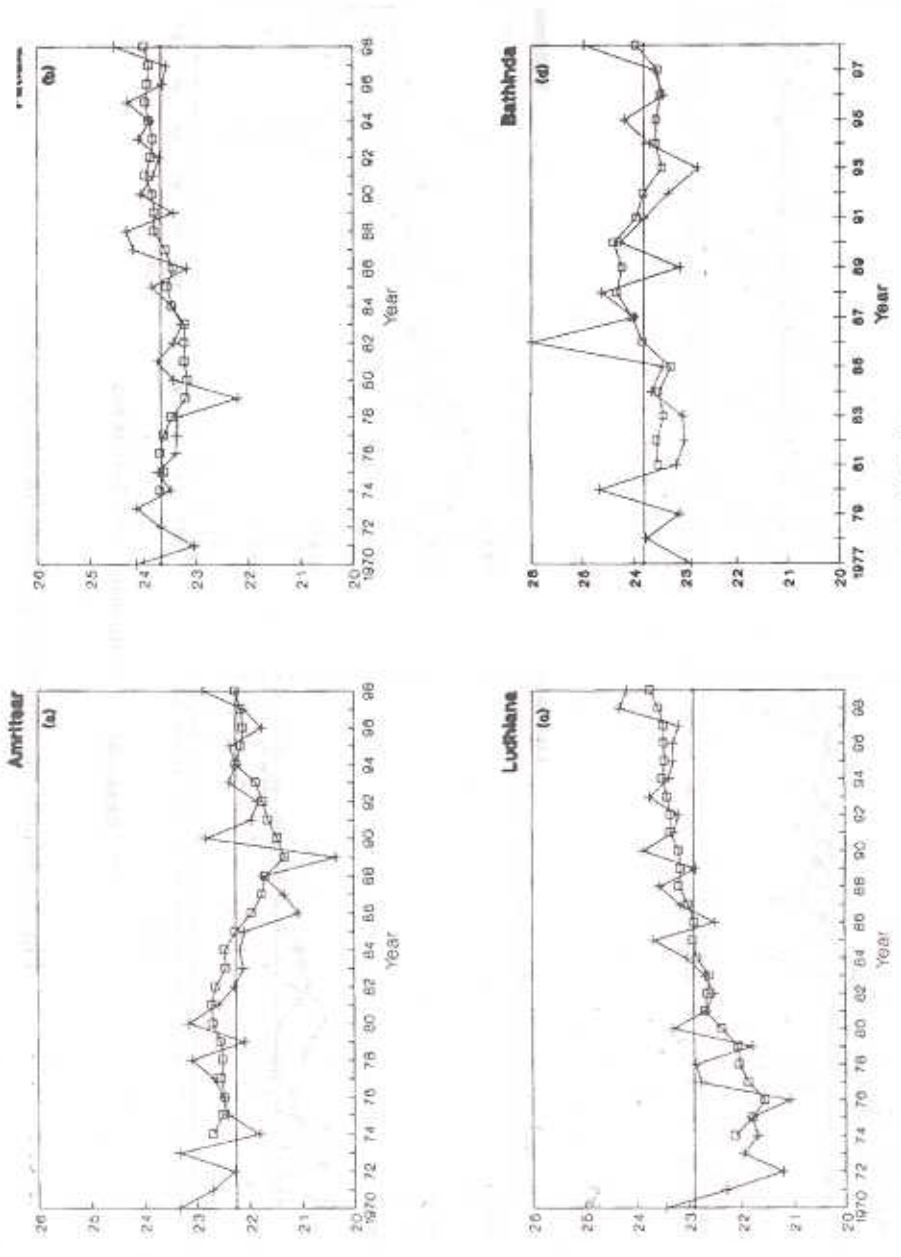

Fig. 4 : Annual minimum temperature for *kharif* season

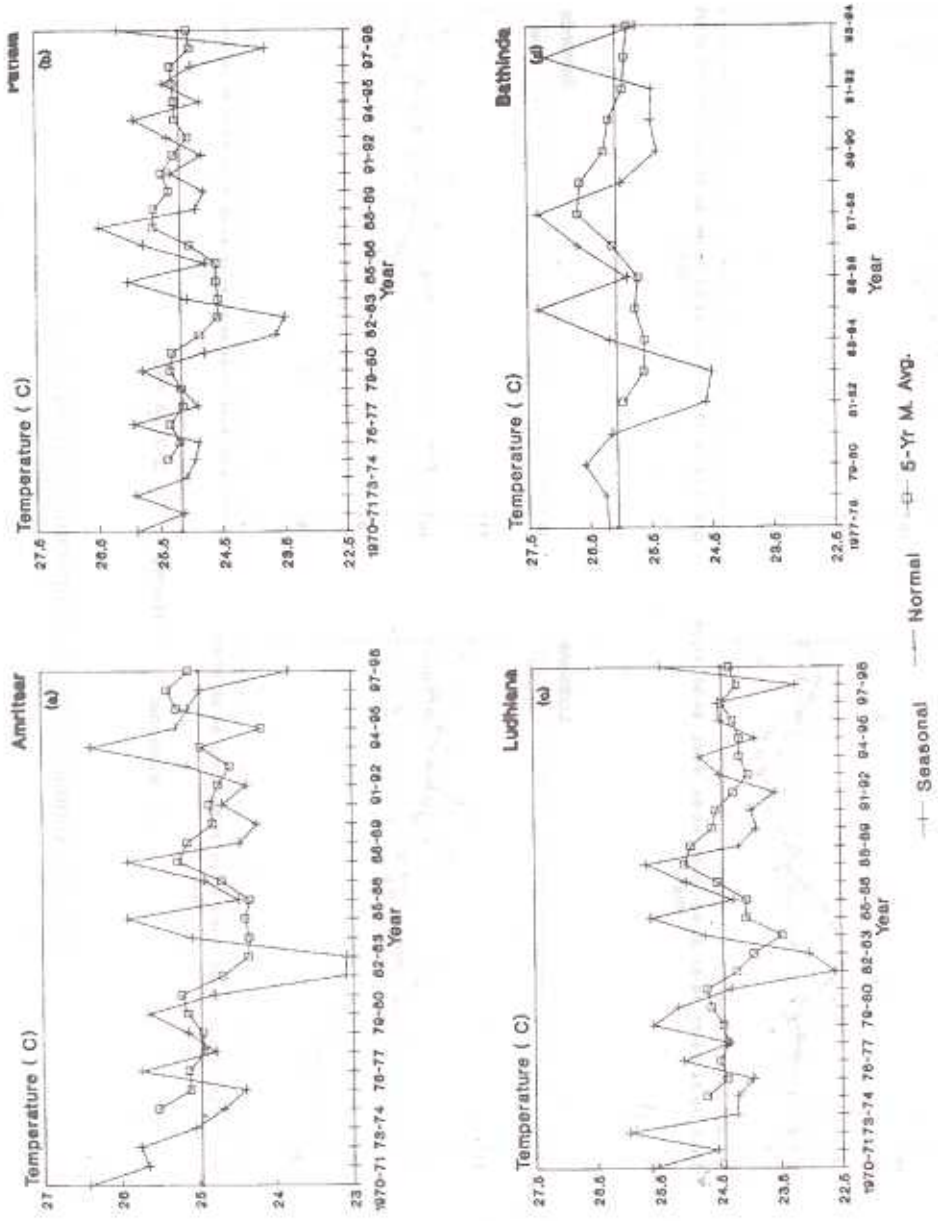

Fig. 5 : Annual maximum temperature for *rabi* season

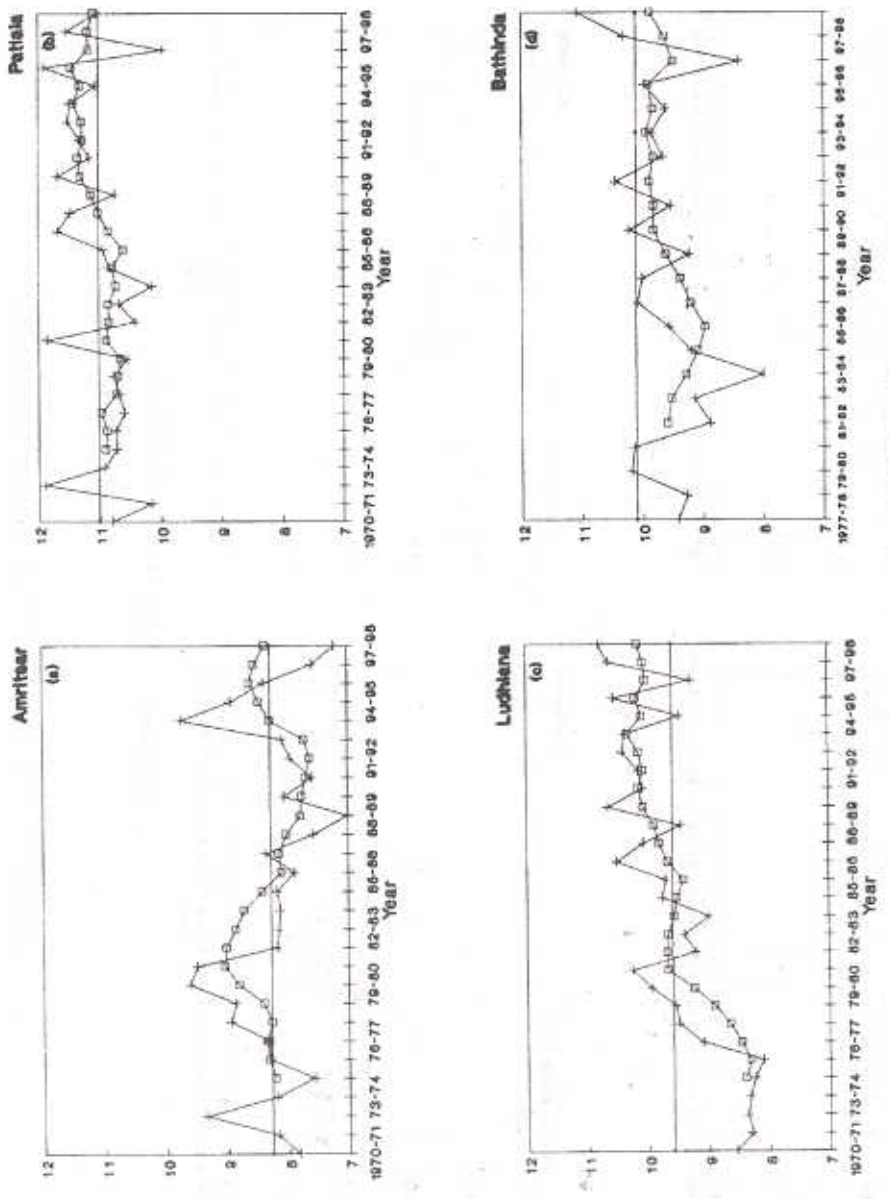

Fig. 6 : Annual minimum temperature for *rabi* season

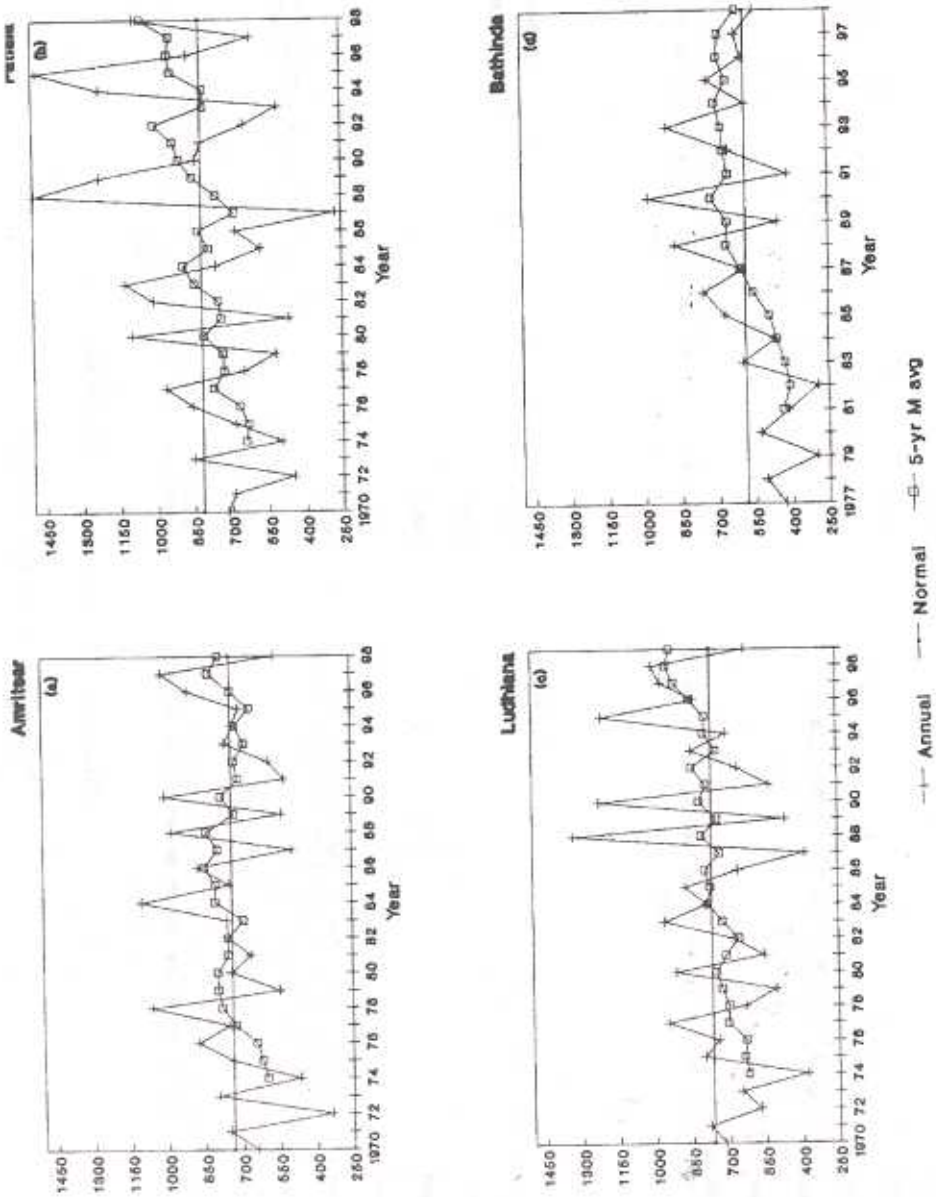

Fig. 7 : Annual rainfall

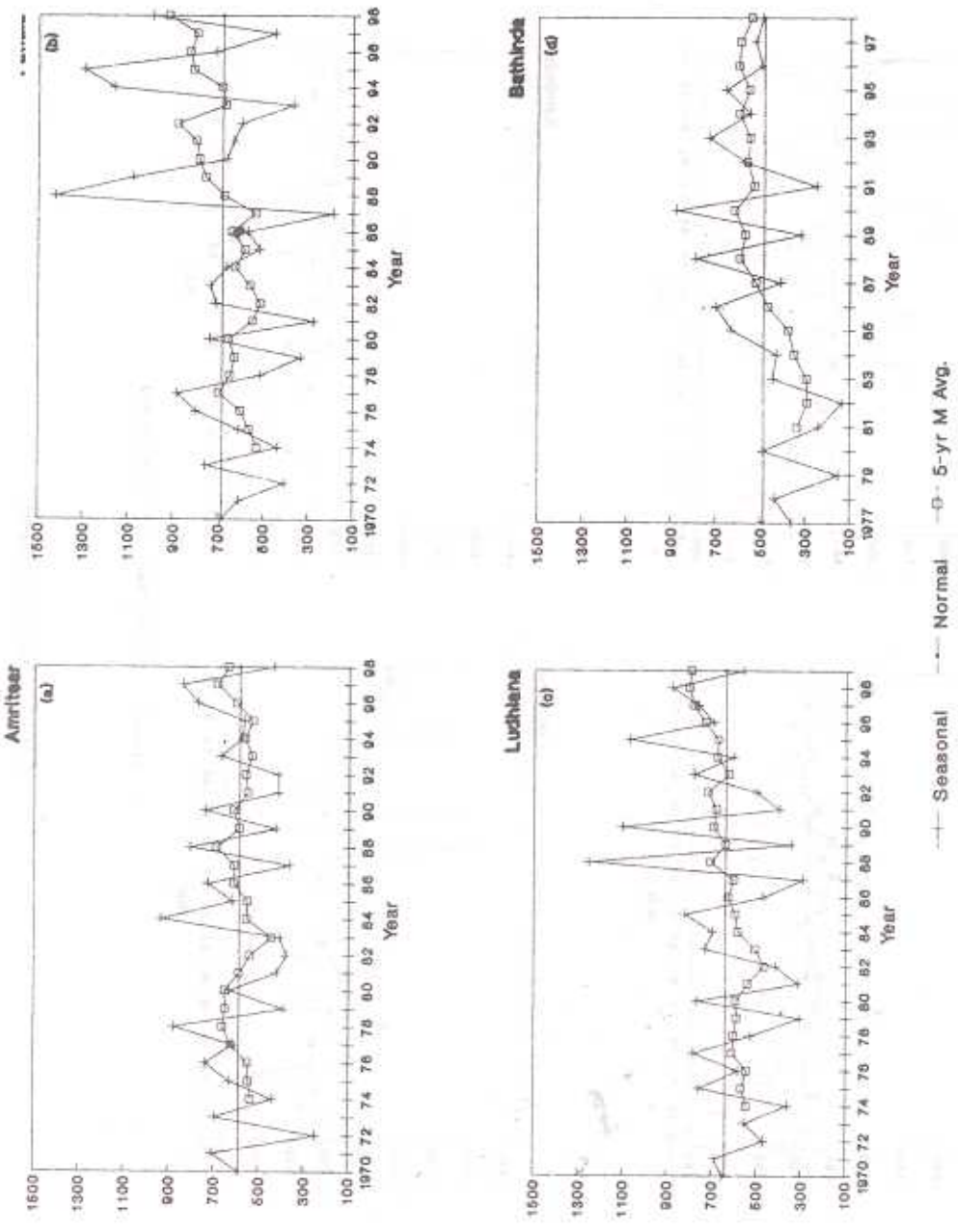

Fig. 8 : *Kharif* season rainfall

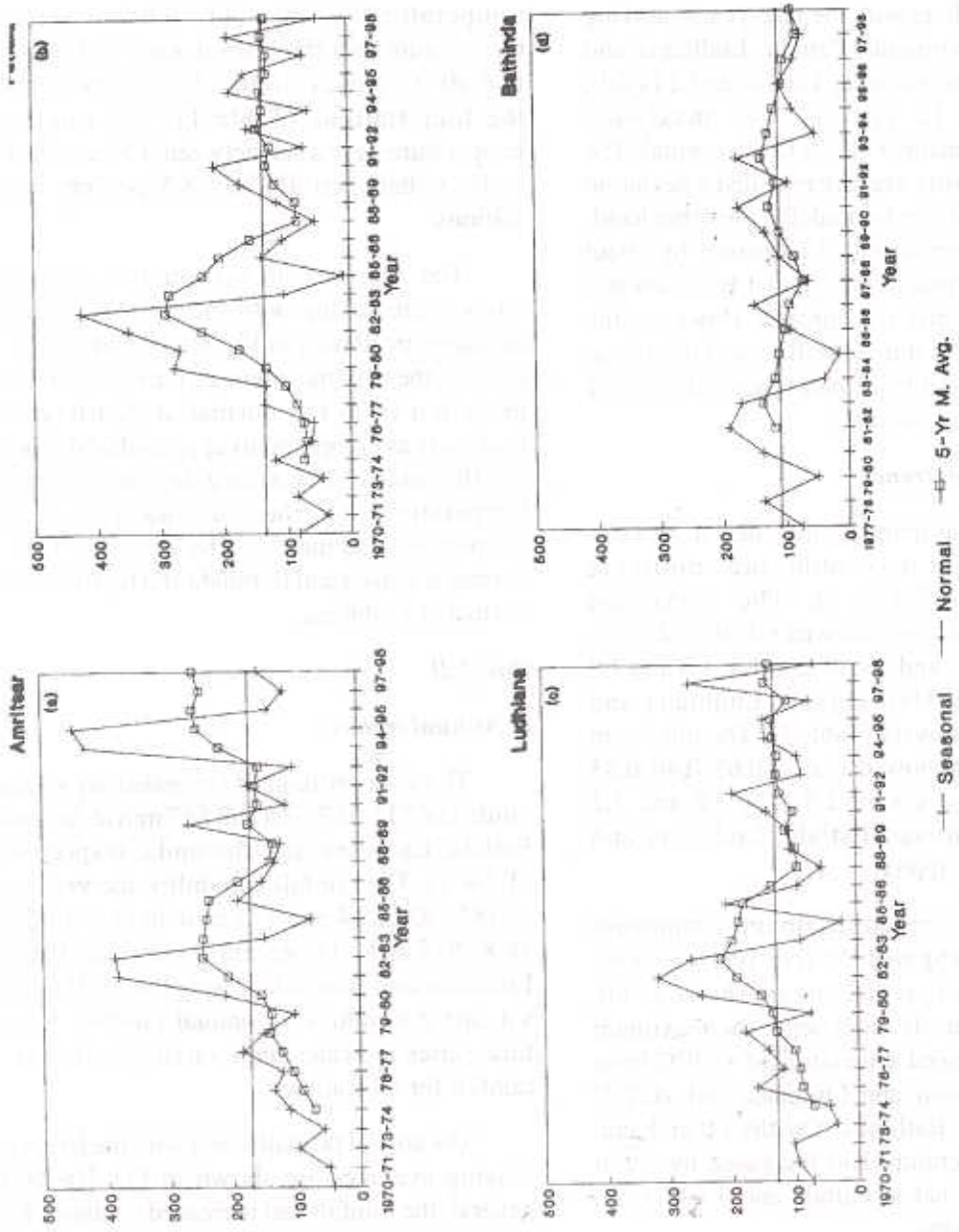

Fig. 9 : *Rabi* season rainfall

The annual maximum / minimum temperatures along with the five-yearly moving averages for Amritsar, Patiala, Ludhiana and Bathinda are shown in fig 1(a - d) and 2 (a - d), respectively. In general, the maximum temperature remained closer to the normal. The five yearly moving average revealed a deviation within ± 0.6°C from normal. On the other hand, minimum temperature had increased by about 0.4°C from normal at Patiala and Bathinda and 1.6°C from normal at Ludhiana. However, the maximum temperature at Patiala and minimum temperature at Amritsar had remained more or less nearer to the normals.

b. Kharif season trends

Like annual temperatures the s.d. and c.v. were small for maximum and minimum temperatures (Table 1). The maximum temperature variability showed s.d. of 0.72, 0.55, 0.62 and 1.03 °C and c.v. of 2.0, 1.6, 1.8 and 2.8 percent at Amritsar, Patiala, Ludhiana and Bathinda, respectively (Table 1). The minimum temperature data showed a s.d. of 0.65, 0.46, 0.83 and 0.77 °C and c.v. of 2.9, 1.9, 3.6 and 3.2 percent at Amritsar, Patiala, Ludhiana and Bathinda, respectively.

The *kharif* season maximum / minimum temperatures along with the five-yearly moving averages for the four stations are shown in Fig 3(a - d) and 4 (a -d). In general, the maximum temperature showed a deviation of +1.0°C from normal at Amritsar and Ludhiana and +0.7°C from normal at Bathinda. On the other hand, minimum temperature had increased by about 0.4°C from normal at Patiala and 1.6°C from normal at Ludhiana.

c. Rabi season trends

The c.v. was comparatively larger for minimum temperature as compared to maximum temperature (Table 1). The maximum temperature data showed s.d. ranging from 0.71 to 0.90 °C and c.v. from 2.8 to 3.3 percent for the four stations (Table 1). The minimum temperature gave a s.d. between 0.55 and 0.81°C and c.v. between 4.8 and 8.5 percent at the stations.

The *rabi* season maximum / minimum temperatures along with the five-year moving averages are shown in Fig 5(a-d) and 6(a-d). In general, the maximum temperature showed small deviation from the normal at Amritsar and Ludhiana as compared to appreciable deviation for the annual and *kharif* season maximum temperatures. On the other hand, minimum temperature had increased by about 0.4°C from normal at Patiala and Bathinda and by 1.6°C from normal at Ludhiana.

Rainfall

a. Annual trends

The data on rainfall revealed an average rainfall of 737, 817, 766 and 587 mm at Amritsar, Patiala, Ludhiana and Bathinda, respectively (Table 1). The rainfall variability showed a s.d. of 186, 300, 234 and 179 mm and c.v. of 25.3, 36.8, 30.5 and 30.5 percent at Amritsar, Patiala, Ludhiana and Bathinda, respectively. The large s.d. and c.v. values for annual rainfall for the time series indicates high variability in annual rainfall for all stations.

The annual rainfall along with the five-year moving averages are shown in Fig 7(a-d). In general, the rainfall had increased by about 120, 150, 150 and 140 mm from normal at Amritsar, Patiala, Ludhiana and Bathinda, respectively.

b. Kharif season trends

The kharif rainfall data revealed an average seasonal rainfall ranging from 484 to 681 mm (Table 1). The rainfall variability gave a s.d. of 176, 287, 237 and 193 mm and c.v. of 29.9, 42.2, 37.2 and 39.9 percent for Amritsar, Patiala, Ludhiana and Bathinda stations, respectively. The large s.d. and c.v. for *kharif* season rainfall for the time series indicates high variability in seasonal rainfall at all the four stations.

The *kharif* season rainfall along with the five-yearly moving averages are shown in Fig 8a - d. In general, the magnitude of increase in *kharif* season rainfall and annual rainfall at all the four stations was similar, thereby indicating that increase in annual rainfall was due to increase in *kharif* season rainfall.

c. Rabi season trends

The rainfall data revealed an average *rabi* season rainfall of 108 to 172 mm at the four locations (Table 1). This indicates that *rabi* season rainfall accounts for 16 to 23 percent of the total rainfall. The rainfall variability showed a s.d. of 109, 95, 73 and 48 mm with c.v. of 63.1, 69.6, 56.8 and 44.0 percent at Amritsar, Patiala, Ludhiana and Bathinda, respectively. The s.d. are comparably smaller but c.v. values were comparably larger for *rabi* season rainfall as compared to annual and *kharif* season rainfall at all the four stations.

The *rabi* season rainfall along with its five-yearly moving averages are shown in Fig 9 (a-b) In general, the rainfall had increased by about 140, 40 and 50 mm from normal at Amritsar, Patiala and Ludhiana.

The analysis in this study indicated that maximum temperature had decreased only slightly. Whereas, minimum temperature and rainfall had shown an increase in recent years at all the four locations of the state of Punjab.

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